CLAIMS

What is claimed is:

1. A power transmission device comprising:

a rotary input member adapted to receive drive torque from a source of drive torque;

a rotary output member adapted to transmit drive torque to an output device;

a torque transmission mechanism operable for transferring drive torque from said input member to said output member, said torque transmission mechanism including a friction clutch operably disposed between said input member and said output member and a clutch actuator for controlling engagement of said friction clutch, said clutch actuator including a rotary operator and a thrust mechanism, said rotary operator having first and second components defining an actuation chamber and a return chamber therebetween, said first component being fixed for rotation with one of said input and output members and said second component adapted to rotate relative to said first component, and said thrust mechanism is operable for applying a clutch engagement force on said friction clutch in response to rotation of said second component relative to said first component; and

an electrohydraulic control system including a fluid pump, an electric motor driving said fluid pump, a control valve disposed in a hydraulic circuit between said fluid pump and said actuation and return chambers, and a control unit for controlling actuation of said control valve for regulating the fluid pressure supplied to at least one of

said actuation and return chambers for controlling rotation of said second component relative to said first component of said rotary operator.

2. The power transmission device of Claim 1 wherein said control unit is operable to control actuation of said control valve for varying the magnitude of the fluid pressure supplied to said actuation chamber as a function of a rotary speed difference between said input and output members.

3. The power transmission device of Claim 1 wherein said control system further includes a pressure sensor which provides a signal to said control unit that is indicative of the value of the fluid pressure in said actuation chamber.

4. The power transmission device of Claim 1 wherein angular movement of said second component to a low pressure position relative to said first component causes said thrust mechanism to be located in a first position for applying a minimum clutch engagement force on said friction clutch, and wherein angular movement of said second component to a high pressure position relative to said first component causes said thrust mechanism to move to a second position for applying a maximum clutch engagement force on said friction clutch, said second component is moveable between its low pressure and high pressure positions due to the magnitude of the fluid pressure delivered from said pump through said control valve to at least one of said actuation chamber and said return chamber.

5. The power transmission device of Claim 4 wherein said torque transmission mechanism further includes a return spring for biasing said thrust mechanism toward its first position which causes said second component of said rotary operator to move toward its low pressure position.

6. The power transmission device of Claim 1 wherein said first component of said rotary operator is a reaction ring having a cylindrical body segment and plurality of first lugs so as to define a plurality of channels therebetween, and wherein said second component of said rotary actuator is an actuator ring having a cylindrical body segment and a plurality of second lugs which extend into said channels so as to define an alternating series of said actuation chambers and said return chambers.

7. The power transmission device of Claim 6 wherein said actuator ring is fixed to a drive component of said thrust mechanism such that rotation of said drive component results in translational movement of a driven component of said thrust mechanism for controlling the magnitude of said clutch engagement force applied to said friction clutch.

8. The power transmission device of Claim 7 wherein said thrust mechanism is a ball ramp unit with a first cam member as its drive component, a second cam member as its driven component, and rollers retained in cam tracks formed between said first and second cam members, wherein said cam tracks are configured to cause translational movement of said second cam member in response to rotary movement of said first cam member, and wherein said second cam member is arranged to cause corresponding movement of an apply plate relative to said friction clutch.

9. The power transmission device of Claim 8 wherein an increase in fluid pressure in said actuation chambers and a reduction in fluid pressure in said return chambers causes said actuator ring and said first cam member to rotate in a first direction relative to said reaction ring for causing corresponding movement of said second cam member from a first position toward a second position for axially moving said apply plate from a released position toward a locked position relative to said friction clutch.

10. The power transmission device of Claim 9 wherein a decrease in fluid pressure in said actuation chambers and an increase in fluid pressure in said return chambers causes said actuator ring and said first cam member to rotate in a second direction relative to said reaction ring for causing movement of said second cam member toward its first position for axially moving said apply plate toward its released position.

11. The power transmission device of Claim 1 wherein said input member is a first shaft in a transfer case and said output member is a second shaft of said transfer case.

12. The power transmission device of Claim 1 wherein said input member is driven by a powertrain of a motor vehicle and said output member is connected to a differential unit of a drive axle assembly.

13. The power transmission device of Claim 1 defining a drive axle assembly having a differential unit interconnecting a pair of axleshafts, and wherein said input member is a differential carrier of said differential unit, said output member is one of said axleshafts, and said torque transmission unit is arranged to adaptively limit slip between said axleshafts.

14. The power transmission device of Claim 1 wherein said hydraulic circuit includes a first flow path supplying fluid from a fluid source to said fluid pump, a second flow path supplying fluid from said pump to said control valve, a third flow path connecting said control valve to said actuation chamber, and a fourth flow path connecting said control valve to said return chamber.

15. The power transfer device of Claim 14 wherein said control valve is operable in a first mode to deliver pressurized fluid through said third flow path to said actuation chamber and vent fluid from said return chamber through said fourth flow path so as to cause said second component to rotate in a first direction relative to said first component from a low pressure position toward a high pressure position for causing said thrust mechanism to increase said clutch engagement force exerted on said friction clutch.

16. The power transfer device of Claim 15 wherein said control valve is operable in a second mode to deliver pressurized fluid through said fourth flow path to said return chamber and vent fluid from said actuation chamber through said third flow path so as to cause said second component to rotate in a second direction relative to said first component toward its low pressure position for causing said thrust mechanism to decrease said clutch engagement force exerted on said friction clutch.

17. The power transmission device of Claim 16 wherein said first component of said rotary operator is a reaction ring having a cylindrical body segment and plurality of first lugs so as to define a plurality of channels therebetween, and wherein said second component of said rotary actuator is an actuator ring having a cylindrical body segment and a plurality of second lugs which extend into said channels so as to define an alternating series of said actuation chambers and return chambers, and wherein said actuator ring is fixed to a drive component of said thrust mechanism such that rotation of said drive component results in translational movement of a driven component of said thrust mechanism for controlling the magnitude of said clutch engagement force applied to said friction clutch.

18. The power transmission device of Claim 14 wherein said electrohydraulic control system further includes a second control valve disposed in said second flow path between said pump and said first control valve, and wherein said second control valve is selectively actuated by said control unit to vary the fluid pressure supplied to said actuation chamber for controlling the angular position of said second component of said rotary operator relative to said first component.

19. The power transmission device of Claim 14 wherein said electrohydraulic control system further includes a second control valve disposed in said third flow path between said first control valve and said actuation chamber, and wherein said second control valve is actuated by said control unit for varying the fluid pressure supplied to said actuation chamber so as to control the angular position of said second component relative to said first component.

20. The power transmission device of Claim 1 wherein said hydraulic circuit includes a first flow path supplying fluid from a fluid source to said pump, a second flow path connecting said pump to said actuation chamber, and a third flow path connecting said pump to said return chamber, and wherein said control valve is disposed in said second path and is operable for regulating the fluid pressure within said actuation chamber so as to control the angular position of said second component relative to said first component for varying the magnitude of said clutch engagement force exerted by said thrust mechanism on said friction clutch.

21. A power transfer device for use in a motor vehicle having a powertrain and first and second drivelines, comprising:

a first shaft driven by the powertrain and adapted for connection to the first driveline;

a second shaft adapted for connection to the second driveline;

a torque transmission mechanism for transferring drive torque from said first shaft to said second shaft, said torque transmission mechanism including a friction clutch operably disposed between said first shaft and said second shaft, and a clutch actuator for engaging said friction clutch, said clutch actuator including a fluid pump, a rotary operator and a thrust mechanism, said rotary operator includes first and second components which define an actuation chamber and a return chamber that are adapted to receive pressurized fluid from said pump, said first component being fixed for rotation with one of said first and second shafts and said second component adapted to rotate relative to said first component in response to the fluid pressure in said actuation and return chambers, and said thrust mechanism is operable for applying a clutch engagement force to said friction clutch in response to rotation of said second component relative to said first component; and

a control system including a motor driving said pump, a control valve disposed in a hydraulic circuit between said pump and said actuation and return chambers, and a control unit for controlling actuation of said motor and said control valve so as to regulate the fluid pressure supplied to at least one of said actuation and return chambers.

22. The power transfer device of Claim 21 wherein said control unit is operable to control actuation of said motor and said control valve for adaptively varying the magnitude of the fluid pressure supplied to said actuation chamber as a function of a rotary speed difference between said first and second shafts.

23. The power transfer device of Claim 21 wherein said control system further includes a pressure sensor which provides a signal to said control unit that is indicative of the value of the fluid pressure in said actuation chamber.

24. The power transfer device of Claim 21 wherein angular movement of said second component to a low pressure position relative to said first component causes said thrust mechanism to be located in a first position for applying a minimum clutch engagement force on said friction clutch, wherein angular movement of said second component to a high pressure position relative to said first component causes said thrust mechanism to move to a second position for applying a maximum clutch engagement force on said friction clutch, and wherein said second component is moveable between its low pressure and high pressure positions due to the magnitude of the fluid pressure delivered from said pump through said control valve to at least one of said actuation and return chambers.

25. The power transfer device of Claim 21 wherein said first component of said rotary operator is a reaction ring having a cylindrical body segment and a plurality of radially extending first lugs which define a series of channels therebetween, wherein said second component is an actuator ring having a cylindrical body segment and a plurality of radially extending second lugs which extend into said channels so as to define a plurality of said actuation chambers and return chambers, wherein said actuator chambers are in fluid communication with an outlet of said control valve, and wherein said fluid pump is operable to draw fluid from a fluid source and deliver high pressure fluid to said control valve such that selective control of said control valve results in rotary movement of said actuator ring relative to said reaction ring.

26. The power transfer device of Claim 25 wherein said actuator ring is fixed to a drive component of said thrust mechanism such that rotation of said drive component results in translational movement of a driven component of said thrust mechanism for exerting said clutch engagement force on said friction clutch.

27. The power transfer device of Claim 26 wherein said thrust mechanism is a ball ramp unit with a first cam member as its drive component, a second cam member as its driven component, and rollers retained in cam tracks formed between said first and second cam member, and wherein said cam tracks are configured to cause translational movement of said second cam member in response to rotary movement of said first cam member for applying said clutch engagement force to said friction clutch.

28. The power transfer device of Claim 27 wherein an increase in fluid pressure in said actuation chambers and a reduction in fluid pressure in said return chambers causes said actuator ring and said first cam member to rotate in a first direction relative to said reaction ring for causing corresponding movement of said second cam member from a released position toward a locked position relative to said friction clutch, and wherein a decrease in fluid pressure in said actuation chambers and an increase in fluid pressure in said return chambers causes said actuator ring and said first cam member to rotate in a second direction relative to said reaction ring for causing movement of said second cam member toward its released position.

29. The power transfer device of Claim 21 wherein said hydraulic circuit includes a first flow path supplying fluid from a fluid source to said pump, a second flow path supplying fluid from said pump to said control valve, a third flow path connecting said control valve to said actuation chamber, and a fourth flow path connecting said control valve to said return chamber.

30. The power transfer device of Claim 29 wherein said control valve is operable in a first mode to deliver pressurized fluid through said third flow path to said actuation chamber and vent fluid from said return chamber through said fourth flow path so as to cause said second component to rotate in a first direction relative to said first component from a low pressure position toward a high pressure position for causing said thrust mechanism to increase the clutch engagement force exerted on said friction clutch, and wherein said control valve is operable in a second mode to deliver pressurized fluid through said fourth flow path to said return chamber and vent fluid from said actuation chamber through said third flow path so as to cause said second component to rotate in a second direction relative to said first component toward its low pressure position for causing said thrust mechanism to decrease the clutch engagement force exerted on said friction clutch.

31. The power transfer device of Claim 29 wherein said electrohydraulic control system further includes a second control valve disposed in said second flow path between said pump and said first control valve, and wherein said second control valve is selectively actuated by said control unit to vary the fluid pressure supplied to said actuation chamber for controlling the angular position of said second component of said rotary operator relative to said first component.

32. The power transfer device of Claim 29 wherein said electrohydraulic control system further includes a second control valve disposed in said third flow path between said first control valve and said actuation chamber, and wherein said second control valve is actuated by said control unit for varying the fluid pressure supplied to said actuation chamber so as to control the angular position of said second component relative to said first component.

33. The power transfer device of Claim 21 wherein said hydraulic circuit includes a first flow path supplying fluid from a fluid source to said pump, a second flow path connecting said pump to said actuation chamber, and a third flow path connecting said pump to said return chamber, and wherein said control valve is disposed in said second path and is operable for regulating the fluid pressure within said actuation chamber so as to control the angular position of said second component relative to said first component of said rotary actuator for varying the magnitude of said clutch engagement force exerted by said thrust mechanism on said friction clutch.

34. A torque transmission mechanism for use in a motor vehicle having a powertrain and a driveline, comprising:

an input member driven by the powertrain;

an output member driving the driveline;

a clutch pack operably disposed between said input and output members;

an apply plate moveable relative to said clutch pack between a first position and a second position, said apply plate is operable in its first position to apply a minimum clutch engagement force on said clutch pack and said apply plate is operable in its second position to apply a maximum clutch engagement force on said clutch pack;

a clutch actuator for controlling movement of said apply plate between its first and second positions, said clutch actuator including a fluid pump, a rotary actuator and a thrust mechanism, said rotary operator having first and second components that are coaxially arranged to define an actuation chamber and a return chamber therebetween which are adapted to receive pressurized fluid from said pump, said first component of said rotary operator is fixed for rotation with one of said input and output members and said second component is adapted to rotate relative to said first component in response to the fluid pressure in said actuation and return chambers, and said thrust mechanism is operable to move said apply plate between its first and second positions in response to rotation of said second component relative to said first component; and

a control system including a control valve disposed in a hydraulic circuit between said pump and said actuation and return chambers and a control unit for controlling actuation of said control valve for regulating the fluid pressure supplied to at least one of said actuation and return chambers.

35. The power transmission device of Claim 31 wherein said control unit is operable to vary the magnitude of the fluid pressure supplied to said actuation chamber as a function of a rotary speed difference between said input and output members.

36. The torque transmission unit of Claim 34 wherein angular movement of said second component to a first position relative to said first component causes said thrust mechanism to locate said apply plate in its first position, wherein angular movement of said second component to a second position relative to said first component causes said thrust mechanism to locate said apply plate in its second position, and wherein movement of said second component from its first position toward its second position is caused by an increase in the fluid pressure delivered by said control valve to said actuation chamber.

37. The torque transmission unit of Claim 34 wherein said first component of said rotary operator is a reaction ring having a cylindrical body segment and plurality of first lugs so as to define a plurality of channels therebetween, and wherein said second component of said rotary actuator is an actuator ring having a cylindrical body segment and a plurality of second lugs which extend into said channels so as to define an alternating series of actuation and return chambers between adjacent pairs of said first lugs.

38. The torque transmission unit of Claim 37 wherein said actuator ring is fixed to a drive component of said thrust mechanism such that rotation of said drive component results in translational movement of a driven component of said thrust mechanism for controlling the magnitude of said clutch engagement force applied by said apply plate to said friction clutch.

39. The torque transmission unit of Claim 38 wherein said thrust mechanism is a ball ramp unit with a first cam member as its drive component, a second cam member as its driven component, and rollers retained in cam tracks formed between said first and second cam members, wherein said cam tracks are configured to cause translational movement of said second cam member in response to rotary movement of said first cam member, and wherein said second cam member is arranged to cause corresponding translational movement of said apply plate relative to said friction clutch.

40. The torque transmission unit of Claim 39 wherein an increase in fluid pressure in said actuation chambers and a reduction in third pressure in said return chambers causes said actuator ring and said first cam member to rotate in a first direction relative to said reaction ring for causing said second cam member to axially move said apply plate from its first position toward its second position relative to said friction clutch, and wherein a decrease in fluid pressure in said actuation chambers and an increase in fluid pressure in said return chambers causes said actuator ring and said first cam member to rotate in a second direction relative to said reaction ring for causing said second cam member to axially move said apply plate toward its first position.

41. The torque transmission unit of Claim 34 wherein said hydraulic circuit includes a first flow path supplying fluid from a fluid source to said pump, a second flow path supplying fluid from said pump to said control valve, a third flow path connecting said control valve to said actuation chamber, and a fourth flow path connecting said control valve to said return chamber.

42. The torque transmission unit of Claim 41 wherein said electrohydraulic control system further includes a second control valve disposed in said second flow path between said pump and said first control valve, and wherein said second control valve is selectively actuated by said control unit to vary the fluid pressure supplied to said actuation chamber for controlling the angular position of said second component of said rotary operator relative to said first component.

43. The torque transmission unit of Claim 41 wherein said electrohydraulic control system further includes a second control valve disposed in said third flow path between said first control valve and said actuation chamber, and wherein said second control valve is actuated by said control unit for varying the fluid pressure supplied to said actuation chamber so as to control the angular position of said second component relative to said first component.

44. The torque transmission unit of Claim 34 wherein said hydraulic circuit includes a first flow path supplying fluid from a fluid source to said pump, a second flow path connecting said pump to said actuation chamber, and a third flow path connecting said pump to said return chamber, and wherein said control valve is disposed in said second path and is operable for regulating the fluid pressure within said actuation chamber so as to control the angular position of said second component relative to said first component for varying the magnitude of clutch engagement force exerted by said thrust mechanism on said friction clutch.